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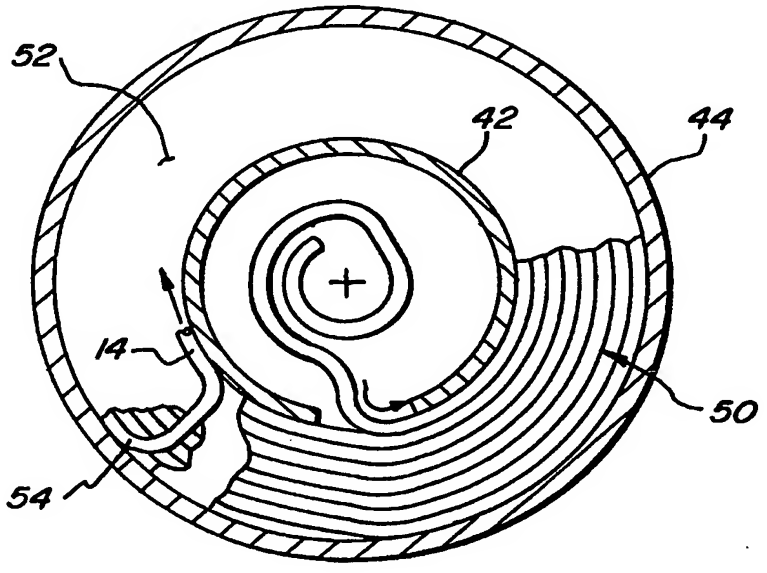
(54) Title: SIGNAL LINE COILING METHOD AND MINE-CLEARING APPARATUS USING SAME

(57) Abstract

A method for coiling a signal transmission line to facilitate deployment of the line is practiced by winding the line in a plurality of sequential spirals about central axes and disposing the spirals in mutual coaxial relation so that adjacent spirals are wound in opposing directions about their respective axes sensed moving along the line from the innermost winding of each spiral to the outermost winding. A transition portion extends from the end of one spiral to the beginning of the next. When there are three or more spirals, the transition portions may be staggered about the common central axis of the spirals. A separator sheet (56) may be placed between the spirals. The signal transmission line may be a line charge (14), e.g., detonating cord, that constitutes part of a mine-clearing apparatus (10). The apparatus (10) may also have deployment structures (16, 30, 34, 22) for deploying the line charge (14) onto a mine field; and initiation structures (24, 26, 34) for initiating the line charge (14).



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SIGNAL LINE COILING METHOD AND MINE-CLEARING APPARATUS USING SAME

BACKGROUND OF THE INVENTION

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application No. 60/051,138, filed June 27, 1997 and entitled "Signal Line Coiling Method and Mine-Clearing Apparatus Using Same".

Field of the Invention

This invention relates to a mine-clearing apparatus and, in particular, to the configuration of a line charge for such an apparatus.

It is well-known that one way to clear a safe path for passage of military and civilian personnel and equipment through a mine field is to initiate the mines along a predetermined path. One method for doing this is to deploy a line charge such as a detonating cord onto the ground surface of the mine field along the desired path. The line charge is initiated and in turn initiates mines placed in close proximity to the path. Once the mines along the path have been initiated, the path may be safely traversed.

Portable devices for enabling field personnel to quickly and easily clear a path through a mine field are known in the art. A typical device of this type comprises a carrying case within which is disposed a deployable line charge, e.g., a length of detonating cord, deployment means for extending the line charge on the ground of the mine field to establish a path to be cleared, and initiation means for initiating the line charge after it is deployed. The line charge is typically stowed in the carrying case in a fan-fold or a figure 8 configuration. Generally, the line charge has a uniform loading of explosive material along its length, or it may comprise a string of lump charges or grenades.

Related Art

U.S. Patent 4,022,396 to Manchester et al, dated May 10, 1977, discloses several methods for splicing together spirals of flat strip material through processing ma-

chinery. Figure 1 shows spirals joined outermost winding-to-outermost winding; innermost winding-to-innermost winding. Figures 6 and 8 show how the outermost winding of a first spiral (25, 33) can be joined to the innermost winding of a second spiral (27, 34) through a spacer (28, 36). Considering the joined spirals as constituting a single length of material, each spiral of material is wound in the same direction about a common axis, sensed moving from one end of the material to the other, so that the connected spirals can be paid circumferentially out one after the other from a motor-driven payoff stand (see Figure 2).

U.S. Patent 5,129,514 to Lilley, Jr., dated July 14, 1992, discloses a figure of eighty pattern for coiling a length of shock tube. According to this pattern, the shock tube is wound alternately in a complex series of sequential portions of figure 8s and ovals, to minimize line twisting.

Portable mine-clearing apparatuses comprising deployable line charges and mechanical safe-arm devices are known.

SUMMARY OF THE INVENTION

One aspect of the present invention relates to a method for coiling a signal transmission line for axial deployment. The method comprises winding the line in a plurality of spirals of increasing radius about central axes and disposing the spirals in mutual coaxial relation, wherein adjacent spirals are wound in opposing directions about the common central axis, as sensed moving along the line from the innermost winding to the outermost winding of the spiral. In a particular embodiment of the invention, the method may comprise winding at least three spirals and providing transition portions that extend from the end of one spiral to the beginning of the next adjacent spiral, and the method may further comprise staggering the transition portions about the common central axis of the spirals. Optionally, the method may comprise placing a separator sheet between adjacent spirals. The method may be practiced with either detonating cord or signal transmission tubes.

This invention also has an apparatus aspect relating to a mine-clearing apparatus that comprises a base, a deployable line charge on the base having a proximal end and a distal end, deployment means connected to the base and connected to the distal end of the line charge, for deploying the line charge onto the mine field, and initiation

means connected to the base and disposed in signal transfer relation to the proximal end of the line charge, for initiating the line charge. The line charge is disposed in a plurality of adjacent coaxial spirals, and each spiral is curved in an opposite rotational direction relative to the adjacent spiral, sensed moving from the proximal end to the distal end. Optionally, each spiral may be wound in a configuration of increasing radius as sensed moving from the proximal end to the distal end. In a particular embodiment, the apparatus may comprise at least three spirals and there may be a transition portion between each pair of adjacent spirals, wherein the transition portions are staggered about the common central axis of the spirals.

According to another aspect of the invention, a line charge, whether or not coiled as described above, may comprise a distal, working portion and a proximal, stand-off portion, and the working portion is connected to the stand-off portion and comprises a loading of explosive material sufficient to initiate a land mine disposed beneath it and the stand-off portion is connected to the initiation means and comprises a lower loading of explosive material than the working portion. The stand-off portion may have a loading of explosive material less than 100 grams per meter, preferably less than 50 grams per meter and, more preferably, of not more than 20 g/m. In particular embodiments, the stand-off portion of the line charge may have a loading of explosive material of not more than 10 percent of the loading of the working portion. The stand-off portion may have a signal-amplifying charge secured to its distal end for initiating the working portion of the line charge.

According to another aspect of the invention, an apparatus as described above may comprise frangible restraining means for keeping the windings of the line charge in place prior to deployment. The restraining means may be connected to and releasable by the deployment means.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partially schematic plan view of a mine-clearing apparatus in accordance with a particular embodiment of the present invention, showing a safe-and-arm portion thereof in a partial cross-sectional view;

Figures 2A-2D are plan views of various stages of the winding of the line charge of the apparatus of Figure 1;

Figure 3A is a ground level elevation view of the apparatus of Figure 1, illustrating deployment of the line charge; and

Figure 3B is a view, similar to Figure 3A, of the apparatus of Figure 1 after deployment of the line charge and before the line charge is initiated.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENTS THEREOF

One aspect of the present invention relates to a method for coiling a rigid, large diameter (e.g., ¼ inch or more) line such as detonating cord or another signal transmission line that must be paid out axially and that cannot easily be folded or subjected to sharp bends. Paying out (or "deploying") the line axially means that the coil does not rotate during deployment, so the line must be drawn obliquely relative to the axis about which the coil is wound, i.e., in a direction not at right angles to the central axis of the spiral, preferably in a direction having a substantial component along the central axis of the spiral. Axial deployment thus differs from circumferential deployment of a coiled line, during which coil is mounted on a rotatable spindle having an axis of rotation which coincides with the axis about which the coil is wound. In circumferential payout, the line is drawn in a direction that is substantially perpendicular to the axis of rotation of the spindle, which turns as the line is drawn. The Manchester et al Patent discussed above shows strip materials coiled for circumferential deployment. The stationary coil and direction of payout of axial deployment are so different from the rotating spindle and circumferential payout of circumferential deployment that those of ordinary skill in the art do not assume that the coiling methods for one are necessarily useful in the other. Broadly speaking, the coiling method of the present invention is achieved by winding the line in a plurality of spirals of increasing radius, wherein each spiral is wound about a central axis in a direction opposite to that of the previous spiral. The spirals are positioned coaxially, one after the other, so that they are arranged sequentially along a common central axis as sensed moving from one end of the line charge to the other. Winding the line in counter-rotating spirals minimizes the overall twisting effect of coiling the line, and thus facilitates deployment of the line.

The coiling method of this invention is particularly useful in the assembly of mine-clearing apparatuses of the type comprising a deployable line charge mounted on a base. The coiling method of this invention provides more compact storage of the line charge on the base than prior art storage configurations used in mine-clearing devices. In addition, the coiling method of this invention helps prevent the cord from overlaying or crossing over itself when deployed over the mine field. This is advantageous because when one portion of a line charge overlays another, the first portion to detonate may sever the other portion without initiating the severed end of the cord. Such an occurrence would leave a portion of the deployed line charge undetonated, so a portion of the minefield would not be cleared as desired when the apparatus is used. Accordingly, the present invention provides a mine-clearing apparatus that is more reliable than similarly configured prior art devices.

A second feature of the present invention provides that a line charge for a mine-clearing apparatus may comprise a proximal, stand-off portion having a loading of explosive material sufficiently low to permit the user of the device to remain nearby when the device is initiated. One end of the stand-off portion is operably connected to an initiation means that may comprise a safe-and-arm device mounted in a casing. The other (distal) end of the stand-off portion is operably connected to the proximal end of a distal, working portion of the line charge, which comprises a sufficient loading of explosive material to initiate nearby land mines when it detonates. The terms "distal" and "proximal" as used herein and in the claims refer to relative distances from the user, who is assumed to remove himself from the apparatus in a direction opposite from the direction in which the line charge is deployed.

These and other features of the invention are described more fully below.

A general view of an apparatus assembled in accordance with the present invention is seen in Figure 1. Mine-clearing apparatus 10 comprises a hinged casing 12 that provides a base for, and contains, the other elements of the apparatus. Casing 12 includes a handle 12a for convenient portage, and the casing may be molded from non-reflective polypropylene, or any other suitable material. In a preferred embodiment, casing 12 comprises an edge gasket 12b which serves to seal the interior of casing 12 against the introduction of unwanted dirt and moisture when the casing is firmly closed. Within casing 12 is mounted a deployable line charge 14 coiled in ac-

cordance with the present invention, about an axis that is substantially perpendicular to level ground. Casing 12 thus provides a base for the line charge. Preferably, the windings of line charge 14 are restrained against inadvertent uncoiling prior to deployment. One way to restrain the windings is to wrap cable ties around them; the ties must, of course, be removed prior to deployment. Another way is to wrap the windings with frangible restraining means, e.g., bands 14a, that are easily severed when line charge 14 is deployed. Bands 14a may comprise Kraft paper that bursts or tears when the line charge is deployed. Alternatively, the windings may be secured by frangible restraining means comprising a hook-and-loop (e.g., Velcro™) fastening system comprising strips of hook fabric and of loop fabric. The coils of line charge may be partially wrapped with a strip of one fabric (e.g., hook fabric) and a strip of the other fabric (e.g., loop fabric) is used to splice together the ends of the strip. The second strip may be connected to the rocket motor so that when the rocket motor is deployed, it peels off the second strip and thus frees the line charge windings.

The line charge 14 is a pliable linear explosive product that generates sufficient explosive force to initiate a mine on which it is disposed as is known in the art, e.g., the line charge may comprise detonating cord. The line charge may have a consistent distribution of explosive material along its entire length, e.g., it may have a uniform core load of explosive material, or it may comprise low core load sections between periodic lump charges or grenades. Casing 12 contains the deployment means for deploying the line charge onto the mine field and the initiation means for initiating the line charge, both mounted therein and thus connected to the base.

The deployment means serves to uncoil line charge 14 and extend it out along the surface of the mine field, as is known in the art. The deployment means of the illustrated embodiment comprises a deployment initiator 16, a deployment signal transmission line (or "deployment line") 18, a squib (not shown) mounted in a safe-and-arm device 34, a rocket motor 22 and a tether 23 for securing line charge 14 to rocket motor 22. When rocket motor 22 is initiated and travels its trajectory, it pulls with it line charge 14 via tether 23. A suitable rocket motor for deploying a line charge having a core load of 109 g/m may be one rated as having an average thrust of 156 Newtons ("N") and a 0.84 second total burn time, for a 133 Newton-second ("Ns") total impulse. Such rocket motors are commercially available. Deployment

means other than rocket motors are known in the art for deploying line charges over a mine field, and any of these may be used with the present invention. For example, it is known to use a rifle bullet trap for this purpose. Since line charge 14 is not rotatably mounted in casing 12, the deployment means must remove line charge 14 in a manner that allows the line to uncoil axially, i.e., that allows line charge 14 to rise above the ground and thus unravel from the coiled configuration in a direction having a vertical component.

Safe-and-arm device 34 is a mechanical safe-and-arm device known in the art. Safe-and-arm device 34 can assure at least two different positions, one in which rocket motor 22 is positioned for firing and in which apparatus 10 is "armed", i.e., in which a signal from deployment initiator 16, deployment line 18 and the squib (not shown) are permitted to initiate rocket motor 22, and another position in which apparatus 10 is "safed", i.e., in which the signal from the squib will not initiate the rocket motor, as described herein.

The rocket motor 22 is initiated by a squib mounted on the end of the deployment line 18. Deployment line 18 comprises any suitable means for conveying an initiating signal from deployment initiator 16 to the squib, e.g., deployment line 18 may comprise a signal transmission tube ("signal tube") or an otherwise suitable fuse. Signal tubes are known to comprise extruded, flexible plastic tubing having a reactive material in the form of a fine powder disposed on the interior wall of the tube. The reactive material is ignited to propagate a signal through the tubing to initiate explosive charges such as those used in detonator caps. Typically, the signal tube is of a small outside diameter and may be formed of a multi-layer tube as illustrated in U.S. Patent 4,328,753 to Kristensen et al, dated May 11, 1982, which shows the cross section of a multi-layer tube comprising an outer layer surrounding an inner layer on the inner surface of which a coating of reactive powder adheres. In the species of signal tube known as shock tube, the reactive powder comprises a pulverulent high explosive material, e.g., PETN or HMX aluminum powder, yielding a high velocity of signal propagation through the tube. In tubes known as low velocity signal tubes, the reactive material comprises a deflagrating material such as manganese/potassium perchlorate, silicon/red lead, as set forth, e.g., in U.S. Patent 4,757,764 to Thureson et al, dated July 19, 1988. Signal tubes are preferred over, e.g., low energy detonating

cords, because they are non-brisant, i.e., they completely contain the brisance of the reactive material therein, and thus pose a minimal threat to the safety of the user. The squib preferably comprises a delay element that serves to obturate the end of the signal tube and to prevent the reaction products from the squib propellant mix from traveling back up the signal tube toward the deployment initiator 16.

The deployment initiator 16, which is mounted on the proximal end of deployment line 18, comprises a device suitable for initiating a signal in the line. For a deployment line comprising shock tube, deployment initiator 16 may comprise a standard direct shoot fitting comprising a spring-loaded firing pin and an M-42 primer. When the firing pin strikes the primer, the primer generates an output that initiates a signal in the shock tube, as is well-known in the art.

Casing 12 also contains initiation means for initiating the line charge after it is deployed. As seen in Figure 1, the illustrated initiation means comprises a line charge initiator 24 and an initiation signal transmission line (or "initiation line") 26 that has a detonator thereon (not shown) disposed in initiation relation to line charge 14. Initiation line 26 may comprise shock tube and line charge initiator 24 may comprise a standard direct shoot deployment initiator 16, like deployment line 18 and deployment initiator 16. Preferably, the detonator on initiator 16 is mounted in the safe-and-arm device 34 and, when safe-and-arm device 34 is "armed", the proximal end of line charge 14 is disposed in signal transfer relation to the detonator on the end of the initiation signal transmission line 26 and, when device 34 is "safed", the detonator is out of position to initiate line charge 14.

Preferably, deployment line 18 and initiation line 26 are over-extruded or wrapped with a common casing to form a dual signal line 30 in a manner well-known in the art. To allow the user to initiate the deployment means and the line charge from a position remote from the mine field, dual signal line 30 may have a suitable length, e.g., 30 to 50 meters, and may be disposed within an initiation reel 32 within which dual signal line 30 may be configured for rapid payout. The deployment initiator 16 and line charge initiator 24 may be secured to initiation reel 32. Initiation reel 32 is removably disposed in casing 12 so that the user can place casing 12 on the ground and walk initiation reel 32 to a safe distance from which to operate the mine-clearing apparatus.

Apparatus 10 further comprises deceleration means for slowing the deployment means when the line charge is near full deployment, to prevent the deployment means from causing stress at the interface of the line charge and safe-and-arm device. In the illustrated embodiment, the deceleration means comprises a tear web strap 36 that is secured to line charge 14 and to casing 12. Strap 36 is folded and sewn upon itself with frangible stitching that can be broken by the force of rocket motor 22 to allow strap 36 to unravel. The stitching subjects the rocket motor to a deceleration force that slows rocket motor 22 when rocket motor 22 and line charge 14 are near the end of their trajectories. Preferably, the trajectory of rocket motor 22 is kept low enough to maximize the deployment of the line charge and to avoid hitting any foliage or other over-hanging objects. Apparatus 10 further includes an anchor stake 38 which is attached to one end of a cable 40. The other end of cable 40 is secured to casing 12. When apparatus 10 is placed in a desired position near or in a mine field, anchor stake 38 can be used to secure the apparatus in place to resist the force imparted thereto when decelerating the line charge.

As indicated above, the line charge used in the apparatus of the present invention is coiled in a particular manner. The method of coiling the line charge is illustrated with reference to Figures 2A through 2D. Figure 2A shows a winding fixture comprising an internal capstan 42 and a containment ring 44. A length of line charge 14 is shown partially wrapped around capstan 42, with an initial or proximal portion 14b thereof partially within the interior of capstan 42. Line charge 14 is wound around capstan 42 in a first direction indicated by arrow 46, i.e., counterclockwise about a central axis 48, to form a planar spiral 50 of increasing diameter, i.e., of diameter that increases as line charge 14 winds around capstan 42. Line charge 14 is wound around capstan 42 to increase the magnitude of spiral 50 until the annular space between capstan 42 and containment ring 44 is substantially full and line charge 14 engages the interior of containment ring 44, as shown in Figure 2B. At this point, first spiral 50 is complete and it may comprise about 30 feet of the line charge. Before coiling continues, an optional separator sheet 52 is placed over spiral 50. Separator sheet 52 serves to facilitate the formation of a subsequent coil by providing a smooth surface on which the subsequent coil can be formed. Preferably, sheet 52 is not secured to line charge 14 or to any other part of apparatus 10, except as a result of

being positioned between coil layers. Separator sheet 52 should be pliable and light in weight so that it does not interfere with the deployment of line charge 14. For example, separator sheet 52 may comprise Kraft paper.

A transition portion 54 of line charge 14 is lifted above the plane defined by spiral 50 and is disposed across the windings of spiral 50 towards the exterior surface of capstan 42. Line charge 14 is then once again wound around capstan 42, but this time in a direction opposite to that of the adjacent spiral 50, i.e., in a clockwise direction about a central axis that is coaxial with axis 48, to create a second spiral (not shown) of increasing radius adjacent to first spiral 50. The two spirals are disposed coaxially and so share a common central axis. When the second spiral is complete, an optional second separator sheet 56 is placed on the second spiral and a second transition portion 58 rises above and across the windings of the second spiral and is disposed towards capstan 42 about which it is wound in the direction of arrow 60 in a direction opposite to that of the preceding spiral, to initiate a subsequent (third) spiral adjacent to the preceding, second spiral. In this case, the third spiral is wound in the same direction as the first spiral, i.e., in a counterclockwise direction. As is evident in Figure 2D, transition portions 54 and 58 do not overlap, i.e., their rotational positions about axis 48 are staggered. In the particular embodiment shown, the transition portions are staggered at about 90° from each other, but any suitable relative axial offset may be used. Staggering the transition portions allows the spirals to lay as flat as possible upon one another. The line charge 14 is wound starting from the distal end, so that the proximal end, including the optional stand-off portion, is wound last. The coiled line charge is then inverted for mounting on the base of the device, and the distal end is secured to the deployment means. In this way, the deployment of the line charge 14 causes the line charge to unravel from the inside of the windings outward. This prevents the tensile forces on the line charge from collapsing partially unwound layers and causing a tangle in the line. Thus, full deployment, i.e., the greatest possible extension of the line charge, is more reliably achieved.

In use, apparatus 10 is carried by field personnel to a safe position in proximity to a mine field. The apparatus is placed on the ground in the desired location and casing 12 is opened as shown in Figure 1. The user stakes the device in place and manipulates rocket motor 22 into position for firing, moving the safe-and-arm device

from a "safed" position to an "armed" position. Then, the user carries initiation reel 32 to a safe position, preferably moving away from casing 12 in a direction opposite to that in which rocket motor 22 will travel, as suggested by arrow 60. As the user retreats from casing 12, dual signal line 30 is paid out. When the user reaches a desired position, the deployment initiator is actuated to initiate rocket motor 22, which carries line charge 14 along a trajectory over the mine field, as suggested in dotted outline in Figure 3A. Once the line charge 14 is deployed, it rests on the surface of the mine field, as shown in Figure 3B. Because of the novel and advantageous method of coiling the line charge within casing 12 as taught herein, deployment is more accurate than in prior art devices and line charge 14 exhibits significantly less twisting, making the apparatus more reliable than prior art devices. With line charge 14 deployed, the user actuates the line charge initiator 24, thus generating a signal in initiation signal transmission line 26 that initiates detonator 28, which in turn initiates the line charge. The line charge initiates the land mines thereunder, and a path is thus cleared along the length of the line charge.

Another feature of the present invention relates to the provision of a stand-off portion of the line charge. According to this aspect of the invention, a stand-off portion of the line charge, i.e., a portion starting at the proximal end of line charge 14 and extending for about 15 meters (about 50 feet) towards the distal end, has a lower core load of explosive material than the remainder of the line charge, i.e., the distal, working portion. The stand-off portion is operably connected to the initiation means at its proximal end and to the working portion at its distal end, and it serves to initiate the working portion of line charge without posing a significant hazard to a user who remains near casing 12 when the line charge is initiated. Generally, the stand-off portion 62 should have a loading of less than about 100 grams per meter of explosive material, preferably less than 50 grams per meter. Preferably, stand-off portion 62 comprises not more than about 10 percent of the linear core load of the distal portion of the line charge. For example, the stand-off portion of line charge 14 indicated at 62 in Figure 3B, may comprise low-energy detonating cord comprising 13.7 grams per meter conventional RDX-based explosive, whereas the distal or working portion 64 of line charge 14, extending from the end of stand-off portion 62 to the distal end of the line charge, may comprise standard detonating cord (which may have 100 grams of

explosive material per meter), or detonating cord having an elevated coreload of explosive material. The core load of explosive material in stand-off portion 62 is low enough to permit a user to remain near the apparatus during use, without injury, yet is sufficient to carry the initiation signal to the working portion of the line charge. For this purpose, the distal end of the stand-off portion may be disposed in signal transfer relation to the proximal end of the working portion. For example, their ends may be knotted together, or they may overlap each other in mutual contiguous relation over a length of about 0.5 meter or more. Optionally, the ends of the two portions may be overwrapped with a common sheath. Stand-off portion 62 puts additional distance between the user and the position at which the line charge generates its full explosive force, thus providing an added degree of safety for the user. The stand-off portion may comprise, for example, part or all of the bottom spiral of the line charge, shown in Figure 2A, whereas the remaining spiral layers may comprise the working portion of the line charge. To allow the use of stand-off portions of even less brisance, i.e., of lower core load, without sacrificing the reliability with which the working portion of the line charge is initiated, the distal end of the stand-off portion may be equipped with an amplifying charge. For example, the stand-off portion may comprise a length of cord having a core load of, e.g., 5 grains per foot hexanitrostilbene (HNS), and may have at its distal end an amplifying charge comprising, e.g., PBXN-5 or some other suitable secondary explosive, in an amount sufficient to initiate the working portion of the apparatus. An optional signal-amplifying detonator 62a is shown in Figure 3B in signal transfer relation to working portion 64, as may be achieved with a conventional connector block, as is seen in U.S. Patent 5,171,935 to Michna et al, dated December 15, 1992.

While the invention has been described in detail with reference to particular embodiments thereof, it will be apparent upon a reading and understanding of the foregoing that numerous alterations to the described embodiment will occur to those skilled in the art and it is intended to include such alterations within the scope of the appended claims.

THE CLAIMS

What is claimed is:

1. A method for coiling a signal transmission line for axial deployment, comprising:

winding the line in a plurality of spirals of increasing radius about central axes and disposing the spirals in mutual coaxial relation, wherein adjacent spirals are wound in opposing directions about the common central axis, as sensed moving along the line from the innermost winding of each spiral to the outermost winding.

2. The method of claim 1 further comprising placing a separator sheet between adjacent spirals.

3. The method of claim 1 or claim 2 comprising winding at least three spirals and providing transition portions between adjacent spirals, the transition portions extending from the end of one spiral to the beginning of the next spiral, and further comprising staggering the transition portions about the common central axis of the spirals.

4. A mine-clearing apparatus comprising:

a base;

a deployable line charge on the base, the line charge having a proximal end and a distal end;

deployment means connected to the base and connected to the distal end of the line charge, for deploying the line charge onto the mine field; and

initiation means connected to the base and disposed in signal transfer relation to the proximal end of the line charge, for initiating the line charge;

wherein the line charge is disposed in a plurality of adjacent coaxial spirals, wherein each spiral is curved in an opposite rotational direction around the common central axis relative to the adjacent spiral, sensed moving from the proximal end to the distal end.

5. The apparatus of claim 4 wherein each spiral has an increasing radius as sensed moving from the proximal end to the distal end.

6. The apparatus of claim 4 further comprising a separator sheet between adjacent spirals.

7. The apparatus of claim 4, claim 5 or claim 6 comprising at least three spirals and a transition portion between each pair of adjacent spirals, and wherein the transition portions are staggered about the common central axis.

8. The apparatus of claim 4 wherein the line charge comprises a distal, working portion and a proximal, stand-off portion, and wherein the working portion is connected to the stand-off portion and comprises a sufficient loading of explosive material to initiate a land mine disposed beneath it and the stand-off portion is connected to the initiation means and comprises a lower loading of explosive material than the working portion.

9. The apparatus of claim 4 further comprising frangible restraining means for keeping the windings of the line charge in place prior to deployment, the restraining means being connected to and releasable by the deployment means.

10. A mine-clearing apparatus comprising:

a base;

a deployable line charge on the base;

deployment means connected to the base for deploying the line charge; and

initiation means connected to the base for initiating the line charge;

wherein the line charge comprises a distal, working portion and a proximal, stand-off portion and wherein the working portion is connected to the stand-off portion and comprises a loading of explosive material sufficient to initiate a land mine disposed beneath it and the stand-off portion is connected to the initiation means and comprises a lower loading of explosive material than the working portion.

11. The apparatus of claim 10 wherein the stand-off portion has a loading of explosive material of not more than 100 g/m.

12. The apparatus of claim 11 wherein the stand-off portion has a loading of explosive material of not more than 50 g/m.

13. The apparatus of claim 12 wherein the stand-off portion has a loading of explosive material of not more than 10 percent of the loading of the working portion.

14. The apparatus of claim 11 comprising a signal-amplifying charge on the distal end of the stand-off portion, in signal transfer relation to the working portion.

15. The apparatus of claim 10 further comprising frangible restraining means for keeping the windings of the line charge in place prior to deployment, the restraining means being connected to and releasable by the deployment means.

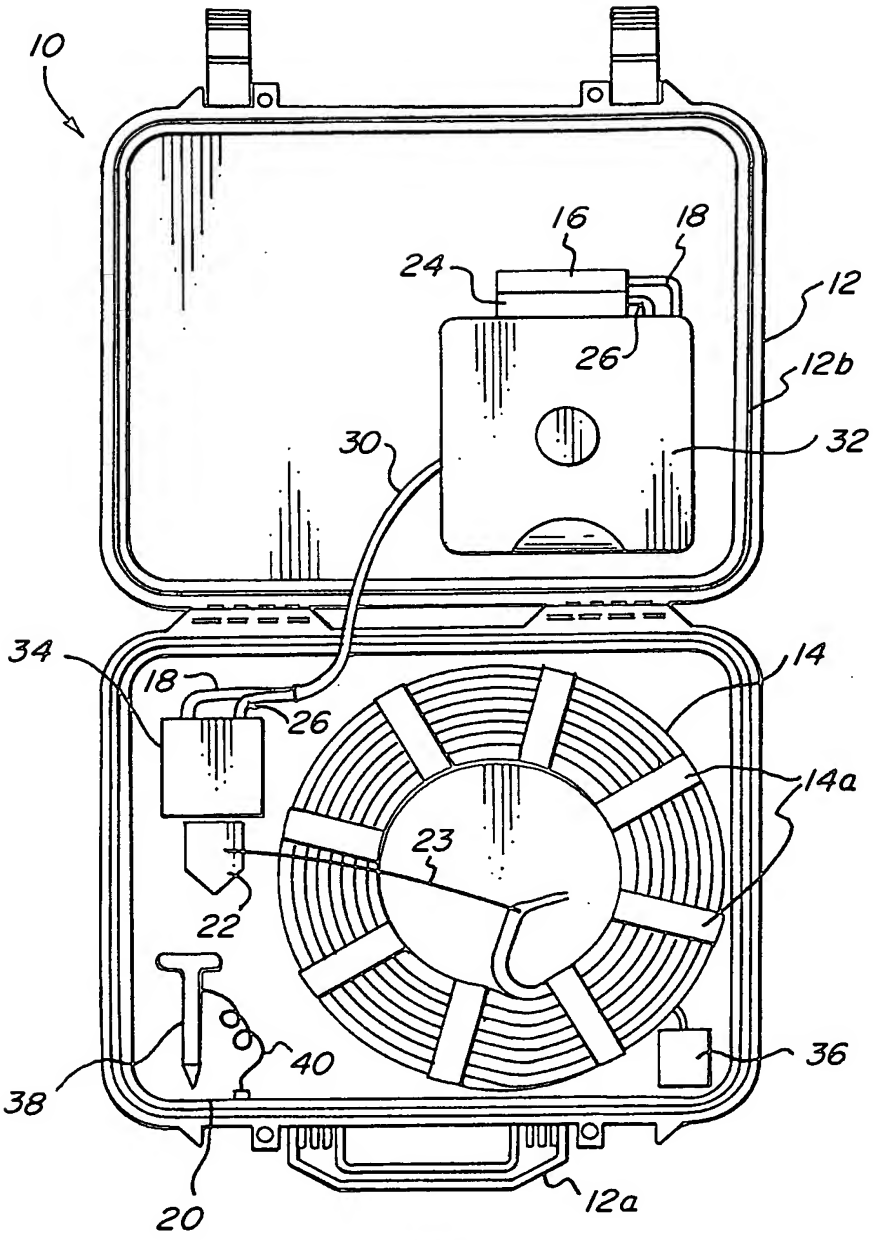

FIG. .1

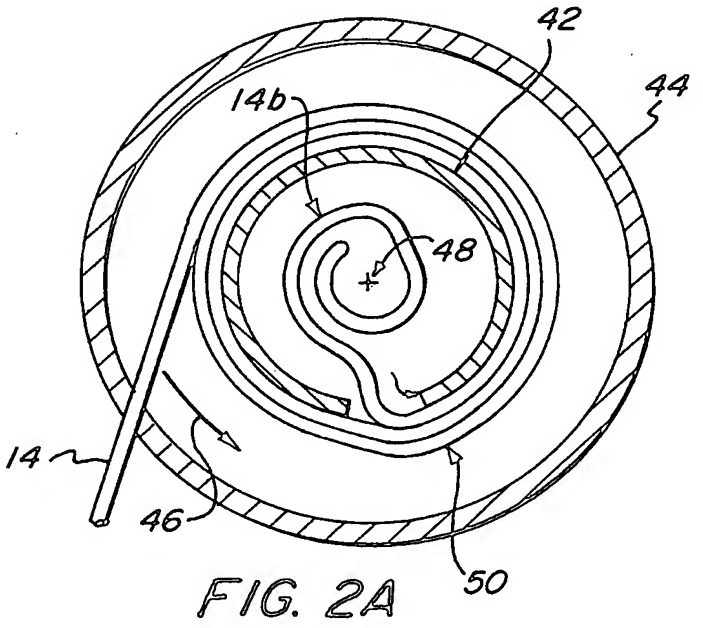

FIG. 2A

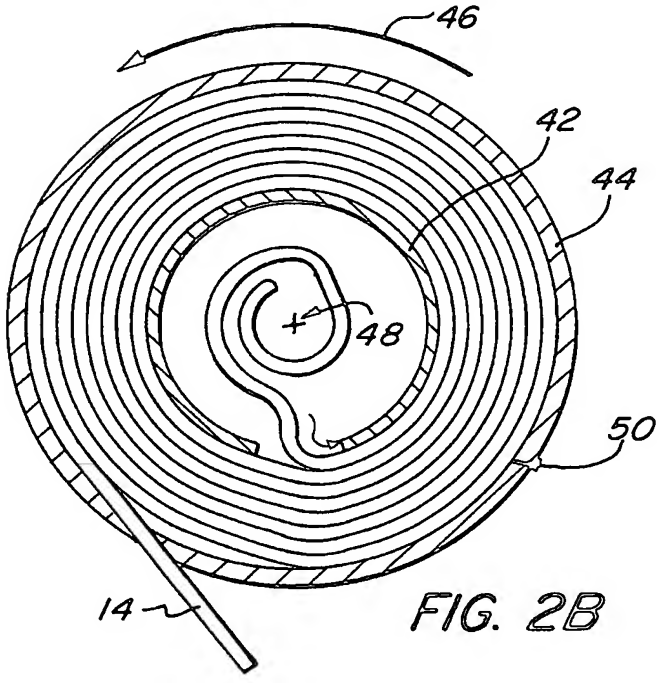

FIG. 2B

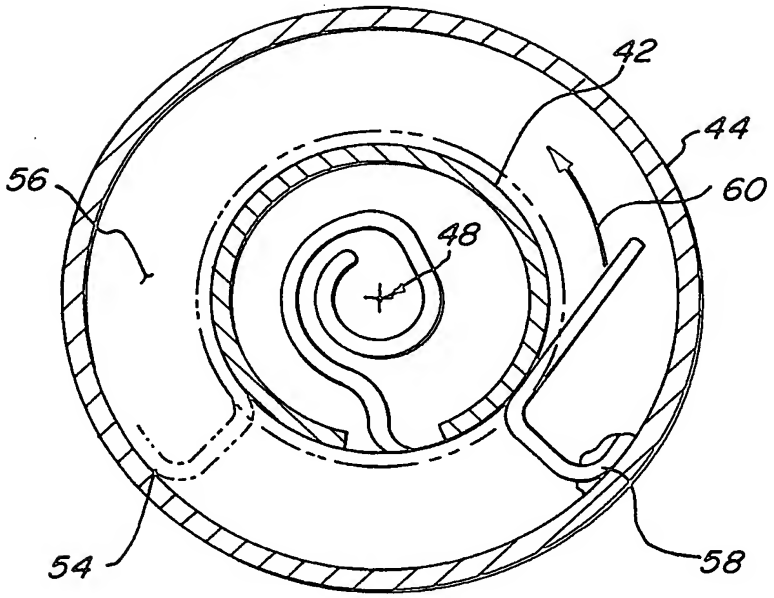

FIG. 2D

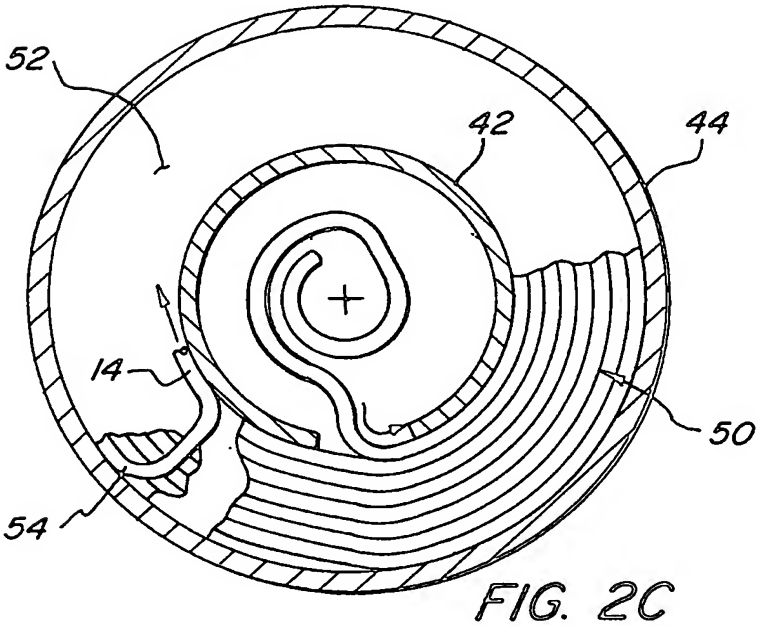

FIG. 2C

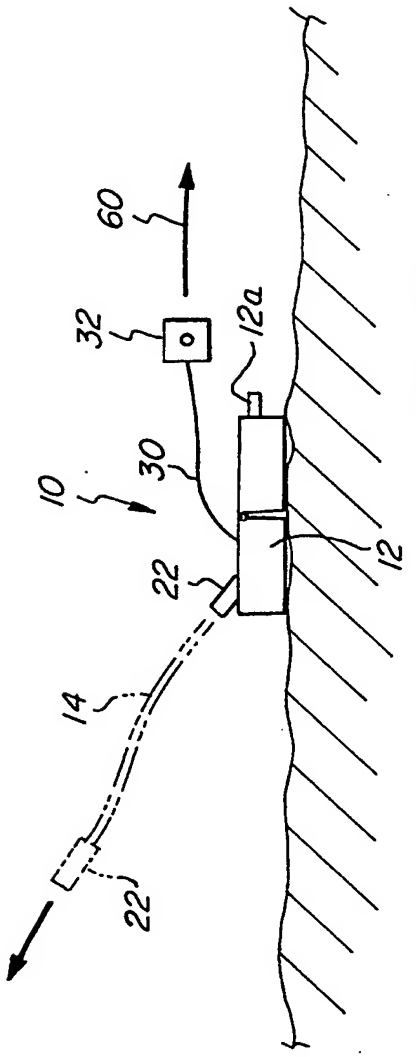

FIG. 3A

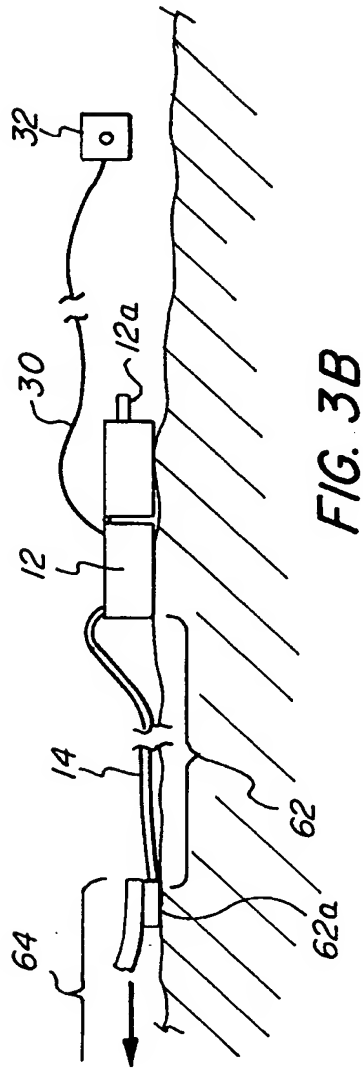

FIG. 3B